10/569763
IAP6 Rec'd PCT/PTO 23 FEB 2006

Organic electronic component with high resolution structuring, and method for the production thereof

The invention relates to an organic electronic component with high resolution structuring, in particular to an organic field effect transistor (OFET) with a low source-drain distance and a method of production capable of mass production.

The switching frequency and/or the switching speed of integrated digital circuits is decisively influenced not least by the channel length "l". There has thus been no lack of attempts to keep this channel length as small as possible, that is to say to provide a chip for an organic electronic component with structuring resolved to the highest possible degree.

Organic electronic components, in particular OFETs with high resolution structuring and a small source-drain distance "l" are known. However, to date these have been produced in complicated process steps that are associated with high costs. These process steps are uneconomic and regularly comprise photolithography, depressions in a lower layer or in the substrate being produced photolithographically such that a conductor track with the required capacity can be formed. These depressions are trough-shaped and do not have sharp contours. The bottom of these depressions remains unchanged.

It is true that a high resolution printing method in which the conductor tracks are introduced into depressions, and which can be applied on a large scale is known from DE 10061297.0, but there is the disadvantage that the depressions which are formed by the application of an embossing die, do not have steep wall surfaces and sharply drawn edges, but are formed more in a trough-shaped fashion and without sharp contours. As a consequence of these soft transitions,

the material introduced into the depression does not, to be accurate, fill only the depression, but it is smeared around the depression and therefore leads to leakage currents. Consequently, the smeared material also cannot be wiped off without a large portion of the material being wiped out of the depression again.

It is an object of the invention to provide an electronic component which can be produced on a large scale and advantageously, and which is made from primarily organic material, in particular an OFET with a high resolution structure and a small source-drain distance.

The object and subject matter of the invention are achieved as an electronic component made from primarily organic material, comprising a substrate, at least one conductor track and/or electrode, in which the at least one conductor track and/or electrode is made from conductive material and applied to a supporting surface, the surface of which is modified and/or roughened by laser treatment.

Moreover, the subject matter of the invention is an organic electronic component in which at least one conductor track and/or one electrode is arranged in a depression of a lower layer, wherein the depression has been produced by means of a laser, that is to say it has steep walls, sharp contours and a rough bottom surface.

Finally, the subject matter of the invention is a method for producing an organic electronic component in which, in order to produce a conductor track and/or an electrode, a lower layer and/or the substrate are/is treated with a laser such that at least one depression and/or one modified region are/is to be found in a lower layer and/or the substrate, the depression having

steep walls, sharp contours and a rough surface at the bottom.

According to one embodiment of the invention, the distance "l" between two electrodes or between an electrode and a conductor track is smaller than 20 µm. This corresponds to `a high resolution of the structuring, which is particularly preferably even below 10 µm, in particular even fewer µm. Owing to the invention, leakage currents between the conductor tracks and/or electrodes are avoided, and the distance "l" therebetween can therefore be minimized.

According to one embodiment of the method, superfluous conductive material is mechanically removed in a process step following the application of the material and/or the filling of depressions with this material, that is to say wiped off, for example, without again removing an appreciable amount of conductive material from the roughened region and/or from the depression with the roughened bottom.

Applying the conductive material and/or filling the depressions can be performed using a variety of techniques: vapor deposition, sputtering, spraying, applying a doctor blade, injection, coating, printing or some other way according to the invention of applying and/or introducing.

According to one embodiment of the method, the lower layer and/or the substrate is treated with a pulsed laser, for example with pulse lengths of a few 10 ns. A few pulses can already be sufficient in this case.

The modified and/or roughened regions and/or depressions produced by laser structuring are distinguished in that the supporting surface for the conductive material is treated with a laser. Consequently, modified regions and/or depressions that

are produced with lasers differ from the regions and/or depressions that have not been treated, or have been treated by embossing, for example, it being impossible, in the latter case, for the superfluous conductive material that is distributed around the depression to be wiped off without large losses.

For the case in which the work function (referred to the semiconductor) of the conductive material is suitable for the planned electronic component, the superfluous material is simply removed on the regions, not changed by laser, of the lower layer and/or the substrate, for example mechanically (by wiping with cloths and/or a rubber roll) and the structuring is terminated.

If the work function is not tuned to the semiconductor, it is additionally possible, for example, to apply a poorly conducting layer whose excess can likewise be removed again with a mechanical method. The combination of these two conductive layers as electrode or as conductor track is now of high conductivity and has the appropriate work function.

The structuring of the lowermost (lower) conductive layer (layers) can be performed in terms of time immediately after their application, and it can also be performed at the same time as the structuring of the upper layers.

The structuring of the lower layers can likewise be performed subsequently, after the structuring of the upper conductive layers (for example an upper layer already structured can be used as etching resistance).

The term "conductive material" is not to be restricted in any way here, since entirely different types of conductive materials have already been successfully used at this juncture.

A metal, an alloy, a metal paste or an organic conductive compound, for example, can be vapor deposited, sputtered on or applied with a doctor blade or applied in some other way as conductive material. The only decisive point is that the introduced conductive material adhere to the surface roughened by the laser.

Named as preferred metals are silver, gold, aluminum, copper, etc. as well as any desired mixtures, alloys of these components that can be applied in gaseous form, or liquid form as ink or metal paste (metal particles in a liquid medium), and also as a solid.

PANI, PEDOT and carbon black are preferred organic materials that can precisely also be combined with a lower conductive layer, for example made from metal.

"Modified" is used here for regions of a lower layer or of a substrate that are changed by laser treatment.

The invention is further explained below in more detail with the aid of three figures that reproduce by way of example and schematically how a conductor track/electrode is produced according to the invention when seen in cross section.

Images A to C show a substrate and/or a lower layer that are treated by a method according to the invention.

A1, B1 and C1 show a cleaned substrate or a cleaned lower layer. This is firstly modified by laser treatment such that a region is produced which has a modified and/or roughened surface and/or a depression (figures A2, B2 and C2). It is also possible for the laser treatment to remove an existing roughness of the

surface, and therefore for the modified region to be less rough than that not modified by laser treatment.

In accordance with figures A2, B2 and C2, however, the roughness of the modified regions is greater than that of the unmodified ones.

Conductive material is applied over a large area in the following process step A3, B3 and C3.

Thereafter, the superfluous material is removed and preferably sharply delineated regions in which conductive material is introduced and/or applied are formed together with others, which are free from conductive material (see figure A4).

In accordance with the embodiment B, in process step B4 yet a further conductive layer, for example made from organic material or functional polymer is applied (Y) to the still unstructured highly conductive, for example metallic, layer. This further conductive layer can now be removed mechanically (B5). If the highly conductive layer cannot be removed mechanically (structured), a different type of method (for example chemical) is selected after process step B5 in order to structure the highly conductive layer. The highly conductive layer (x) is covered at the "modified" or roughened positions and cannot be removed here (B5). The combination of the highly conductive (for example metallic) layer and the conductive (for example polymeric) layer is present in structured form in (B6) after the chemical structuring (for example an etching process).

A further conductive layer is likewise applied at C4, and subsequently the two conductive layers are mechanically structured (C5).

The process according to the invention can be used to produce conductive structures which:

- consist of a number of layers (of different conductivity) in order, for example, to ensure the matching work function,
- are highly conductive or highly conductive in the "packet",
- are cost-effective, since only a few (3, 4, 5) process steps are required,
- have the required resolution (smallest possible structure), and
- are based on a process that is fast and capable of mass production.

The advantages also reside in the simple production method, since only 3 process steps are required (for example laser structuring, application of conductive layer, structuring of the conductive layer). For example, it is possible by using metallic conductors (solid or liquid) once again in combination with further conductors made from organic material, for example, to produce very highly conductive small structures without a voltage drop along the conductor tracks becoming problematical. In addition, the work function can be matched. The circuit size can be minimized using this technique, as a result of which the costs are likewise reduced to the same extent.

The substrate is, for example, drawn through between a number of rolls using the roll-to-roll method. Depressions and/or modified or roughened regions in the substrate or a lower layer are then produced through a mask in the first working step with the aid of a laser, for example an excimer laser. If appropriate, the excimer laser is equipped with optical lens systems such that the depressions/regions are not necessarily imaged with the same size as prescribed by the mask.

Any conductive material possibly present between the depressions/regions is removed during mechanical structuring with the aid of a suction roll using the roll-to-roll method, for example. For example, the roll rotates more slowly than the other rolls so that wiping is done effectively.

The term "organic material" or "functional material" or "(functional) polymer" here comprises all types of organic, organometallic and/or organic/inorganic polymers (hybrids), in particular those that are denoted in English, for example, as "plastics". All types of substances are involved, with the exception of the semiconductors, which form the classic diodes (germanium, silicon). Consequently, no restriction in a dogmatic sense to organic material as material containing carbon is envisaged, but rather the wide use of silicones, for example, is also held in mind. Furthermore, the term is not intended to be subject to any restriction with regard to molecule size, in particular to polymeric and/or oligomeric materials, but the use of small molecules is also entirely possible. The word component "polymer" in functional polymer is historically conditioned and to that extent says nothing about the presence of an actually polymeric compound.

The invention presents for the first time a method with the aid of which an organic electronic component such as an OFET, which can by all means also comprise metallic components and layers, can be produced with a high switching speed and high reliability in an economic fashion. It has emerged that depressions and/or regions that are produced with a laser respond differently to the application of conductive organic material than do the conventional depressions/ structurings, and that therefore conductor tracks of organic and metallic nature can be produced more

quickly and more effectively with this method than using other methods.